

# **January 1997**

## **Preliminary Data Summary**

by      Field Research Facility

U.S. Army Corps of Engineers  
Waterways Experiment Station  
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# Preface

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This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

**Data from these reports are now available via the World Wide Web at  
<http://www.frf.usace.army.mil>**

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Please note the new web address, <http://www.frf.usace.army.mil>

Your comments and criticisms are welcome.

# Introduction

## 1

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The U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's (CHL) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919)261-6840 ext.222 ([c.baron@cerc.wes.army.mil](mailto:c.baron@cerc.wes.army.mil)).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

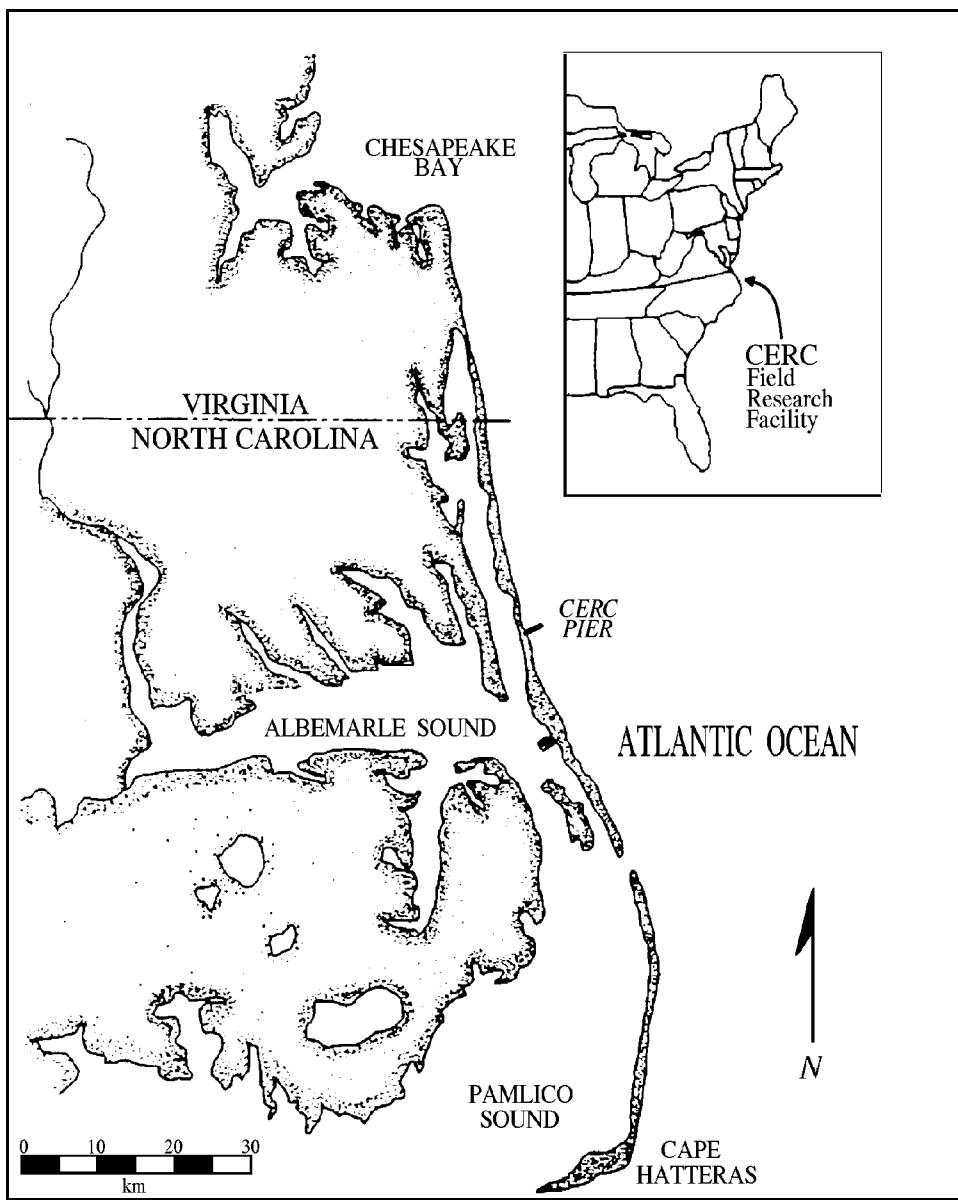


Figure 1. FRF Location Map

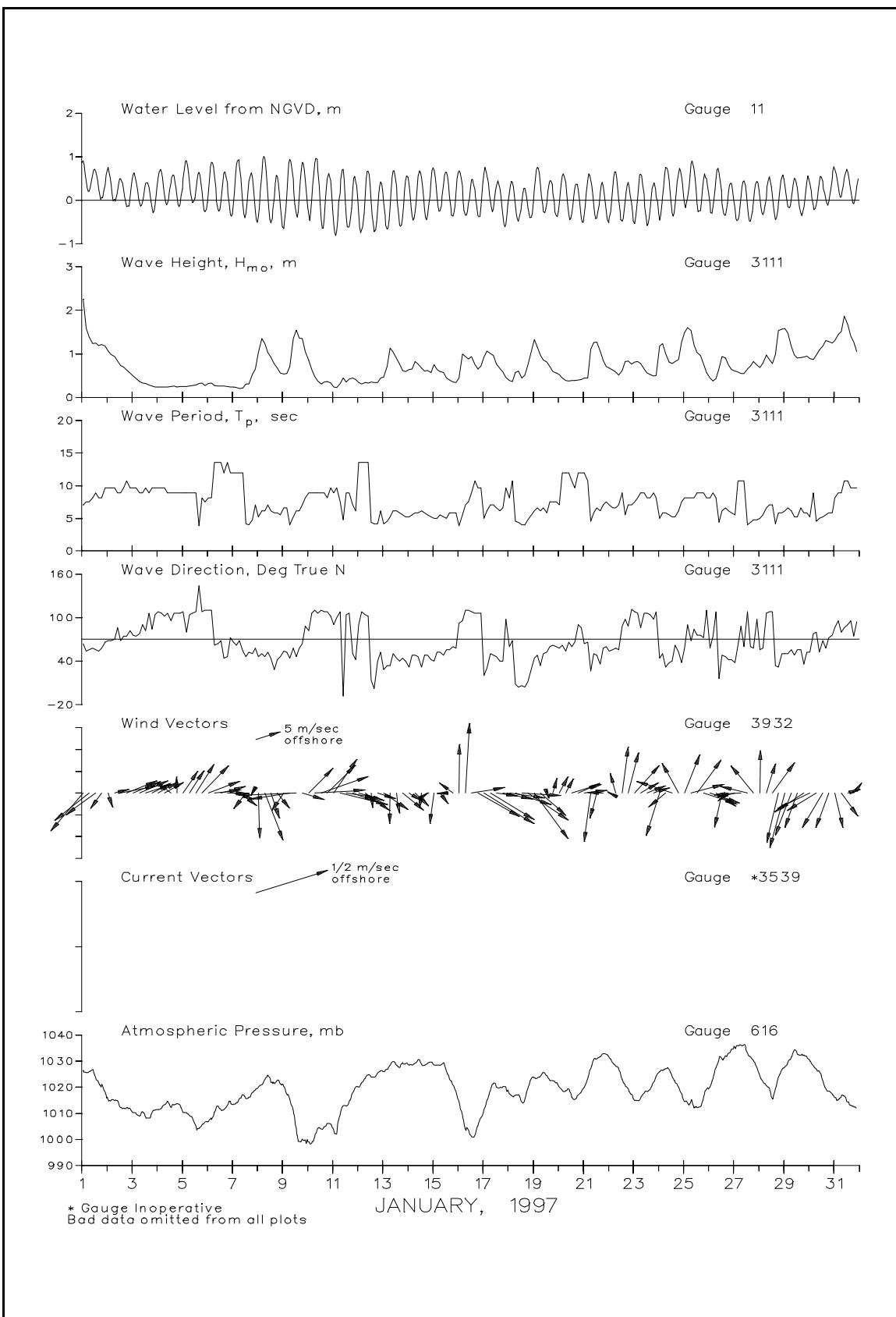


Figure 2. Month at a Glance

**Table 1**  
**Instrument Status/Data Availability**

|   |   | January 1997        |                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---------------------|----------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|   |   | Day of the month    |                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Gauge   | ID  | Description/Remarks | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |   |   |   |
| 616   | Atmospheric Pressure  | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 604   | Precipitation   | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 624   | Air Temperature   | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 3932  | Anemometer  | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 641   | Pressure Gauge<br>on FRF pier                                 | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 625   | Baylor staff<br>on FRF pier                                   | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 3111  | 8 Meter Array<br>309 m north of FRF                           | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 111   | Pressure Gauge<br>center of<br>8 Meter Array                  | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 630   | Waverider buoy<br>4.0 km offshore                             | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| 3539  | Current meter<br>343 m north of FRF<br>pier (1.6 km offshore) | Gauge Status        | -                    | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |   |   |   |   |   |
|   |   | Data Collected      | -                    | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |   |   |   |   |   |
| 11  | NOAA tide gauge<br>at end of pier                             | Gauge Status        | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
|   |   | Data Collected      | *                    | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |
| Visual Observations<br>(daily oceanographic and<br>meteorological observations) |   |                     | Daily<br>observation | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |   |   |
| Gauge Status      * = Operational      / = Partial      - = Non-Operational     |   |                     |                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Data Collected    * = All      / = Partial      - = None                        |   |                     |                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Visual Observations    * = Complete      / = Partial      - = None              |   |                     |                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

**Table 2**  
**Gauge Locations**

| Gauge* | Description                                  | * Latitude      | * Longitude     | * FRF Coordinates        | * Gauge Depth | * Water Depth      |
|--------|--|-----------------|-----------------|--------------------------|---------------|--------------------|
| ID *   |  | * Degrees N     | * Degrees W     | * CrossshoreT Longshore* | NGVD, m       | * NGVD, m          |
|        |  | *               | *               | *                        | m             | *                  |
| 616    | * Atmospheric Pressure*                      | 36 10' 57.03"   | * 75 45' 5.50"  | * 11.60                  | * 569.00      | * -----            |
| 3932   | * Anemometer                                 | * 36 11' 1.23"  | * 75 44' 43.07" | * 585.20                 | * 517.30      | * 19.50            |
| 641    | * Pressure Gauge                             | * 36 10' 57.71" | * 75 44' 56.23" | * 239.11                 | * 516.64      | * -1.64            |
| 625    | * Baylor Staff                               | * 36 11' 1.04"  | * 75 44' 43.72" | * 568.00                 | * 516.64      | * Surface * -8.36  |
| 3111   | * 8 Meter Array North                        | * 36 11' 19.14" | * 75 44' 36.41" | * 915.23                 | * 990.16      | * -7.50            |
|        | * 8 Meter Array South                        | * 36 11' 11.28" | * 75 44' 33.28" | * 914.20                 | * 735.37      | * -7.42            |
|        | * 8 Meter Array East                         | * 36 11' 13.70" | * 75 44' 32.56" | * 954.51                 | * 800.58      | * -7.62            |
|        | * 8 Meter Array West                         | * 36 11' 12.48" | * 75 44' 37.11" | * 834.66                 | * 800.37      | * -6.98            |
| 111    | * Pressure Gauge in<br>* center of 8 M Array | * 36 11' 14.06" | * 75 44' 34.39" | * 914.43                 | * 825.52      | * -7.76            |
| 630    | * Waverider Buoy                             | * 36 10' 5.10"  | * 75 41' 59.30" | * 3934.96                | * -2400.81    | * Surface * -17.00 |
| 3539   | * Current Meter                              | * 36 11' 23.57" | * 75 44' 9.12"  | * 1605.80                | * 907.60      | * -11.60           |
| 11     | * NOAA Tide Gauge                            | * 36 11' 1.25"  | * 75 44' 42.60" | * 596.49                 | * 514.20      | * Surface * -7.62  |
| R      | R  | R               | R               | R                        | R             | R                  |

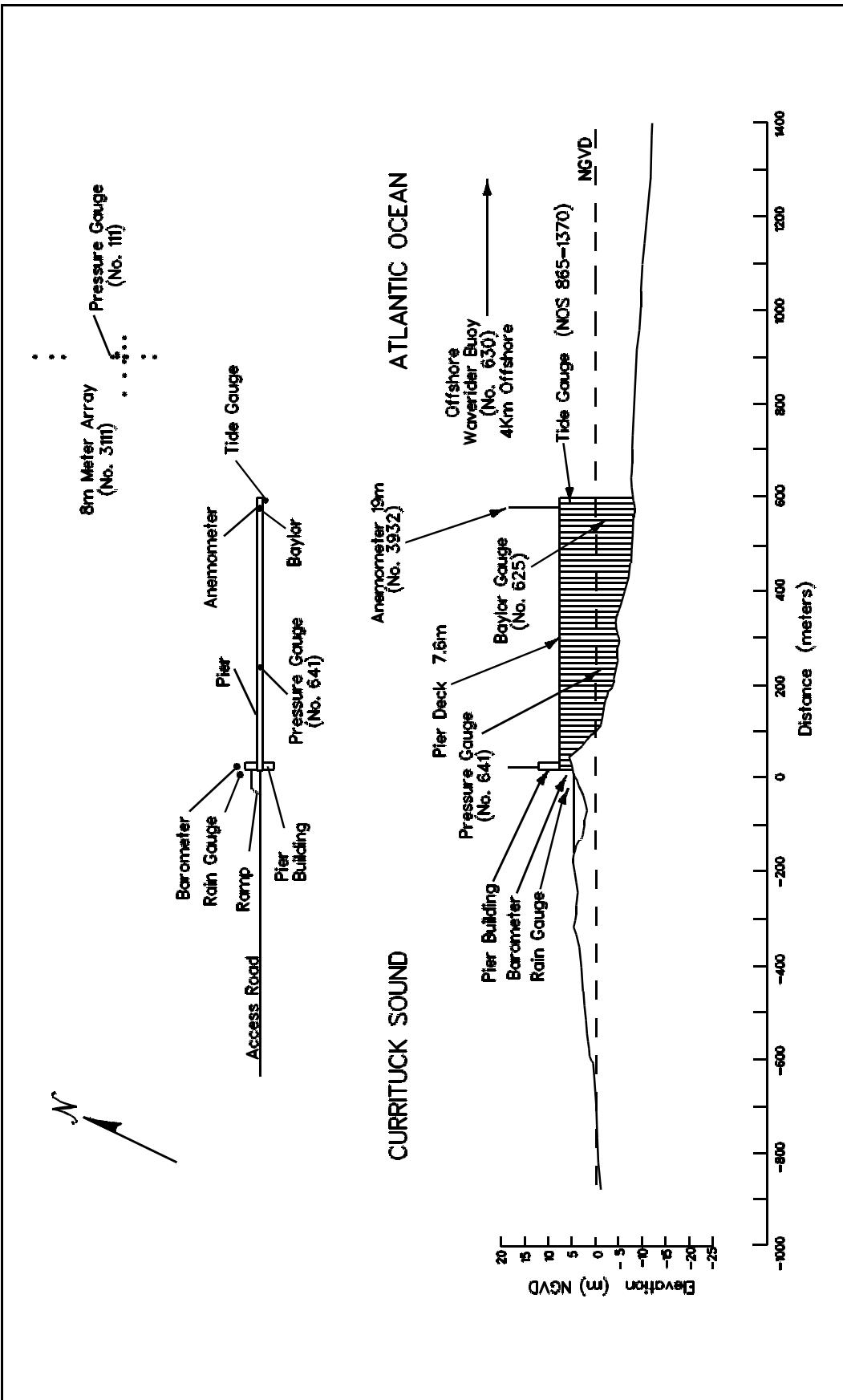


Figure 3. Instrument Locations, Elevations From NGVD

# Meteorological Data

## 2

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A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

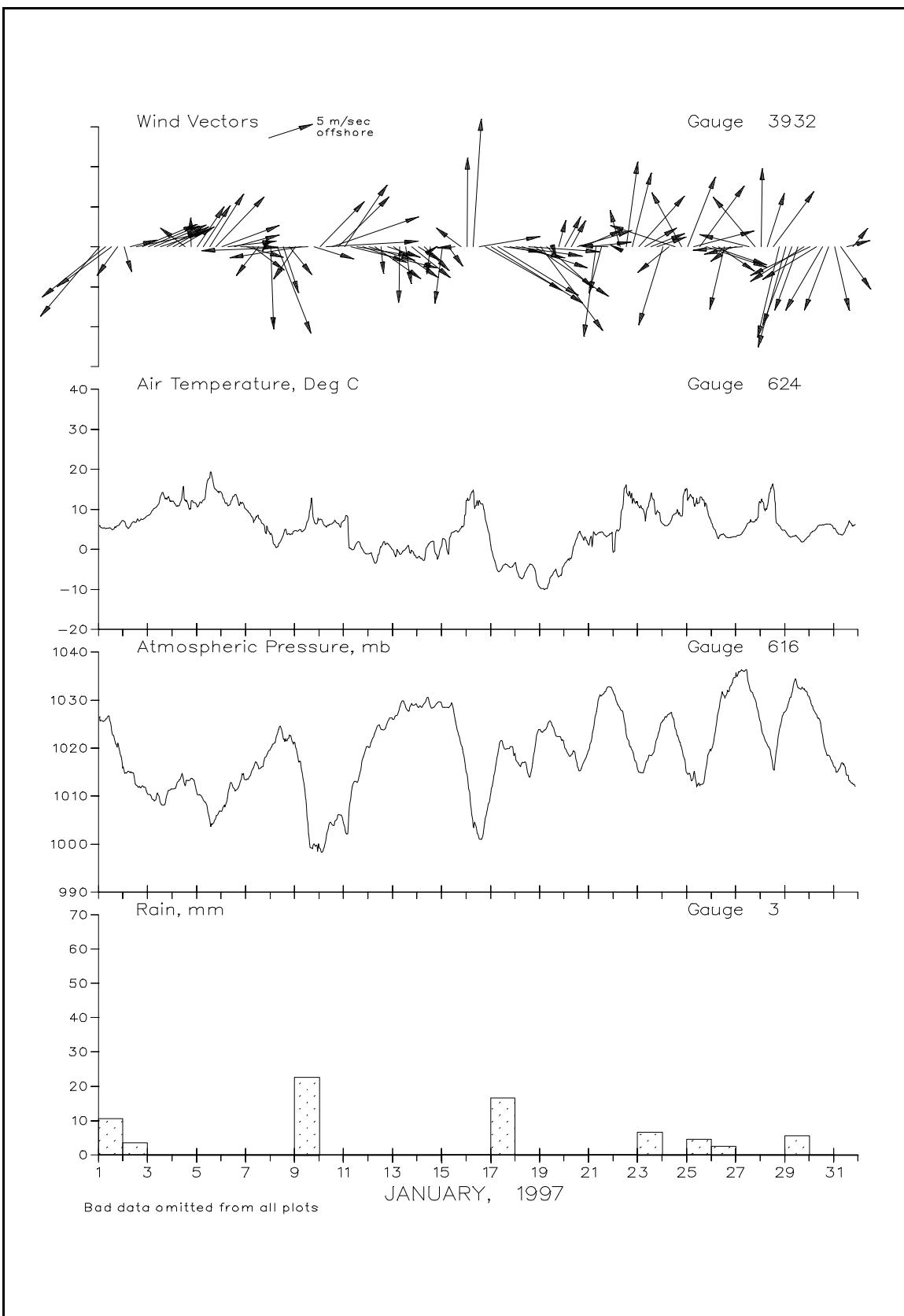


Figure 4. Meteorological Monthly Summary

**Table 3**  
**Meteorological Data**

| Jan 1997 |      |                     |                          |                      |                    |                     |
|----------|------|---------------------|--------------------------|----------------------|--------------------|---------------------|
| Day      | Hour | Wind Speed<br>m/sec | Wind Direction<br>deg TN | Temperature<br>deg C | Atm Pressure<br>mb | Precipitation<br>mm |
| 1        | 100  | 11                  | 36                       | 6.0                  | 1026.5             | 0                   |
|          | 700  | 9                   | 1                        | 5.3                  | 1026.0             | 11                  |
|          | 1300 | 8                   | 1                        | 5.1                  | 1023.7             | 0                   |
|          | 1900 | 4                   | 32                       | 6.0                  | 1021.1             | 0                   |
| 2        | 100  | 3                   | 1                        | 7.0                  | 1015.2             | 0                   |
|          | 700  | 3                   | 253                      | 5.8                  | 1014.9             | 4                   |
|          | 1300 | 7                   | 256                      | 6.8                  | 1012.3             | 0                   |
|          | 1900 | 6                   | 244                      | 7.5                  | 1012.2             | 0                   |
| 3        | 100  | 6                   | 244                      | 8.5                  | 1010.4             | 0                   |
|          | 700  | 6                   | 243                      | 10.3                 | 1009.0             | 0                   |
|          | 1300 | 5                   | 248                      | 13.3                 | 1008.6             | 0                   |
|          | 1900 | 4                   | 239                      | 12.5                 | 1010.4             | 0                   |
| 4        | 100  | 5                   | 237                      | 12.1                 | 1011.5             | 0                   |
|          | 700  | 4                   | 236                      | 11.0                 | 1013.4             | 0                   |
|          | 1300 | 4                   | 131                      | 12.1                 | 1012.2             | 0                   |
|          | 1900 | 4                   | 178                      | 12.1                 | 1013.8             | 0                   |
| 5        | 100  | 6                   | 209                      | 10.6                 | 1010.4             | 0                   |
|          | 700  | 6                   | 208                      | 12.4                 | 1009.2             | 0                   |
|          | 1300 | 8                   | 208                      | 18.0                 | 1005.1             | 0                   |
|          | 1900 | 8                   | 219                      | 14.9                 | 1005.5             | 0                   |
| 6        | 100  | 7                   | 246                      | 14.0                 | 1006.9             | 0                   |
|          | 700  | 5                   | 262                      | 10.9                 | 1010.5             | 0                   |
|          | 1300 | 5                   | 253                      | 13.3                 | 1011.5             | 0                   |
|          | 1900 | 4                   | 271                      | 11.9                 | 1013.2             | 0                   |
| 7        | 100  | 4                   | 288                      | 10.0                 | 1013.5             | 0                   |
|          | 700  | 4                   | 310                      | 8.0                  | 1015.7             | 0                   |
|          | 1300 | 4                   | 34                       | 7.7                  | 1015.7             | 0                   |
|          | 1900 | 1                   | 26                       | 5.5                  | 1018.0             | 0                   |
| 8        | 100  | 10                  | 358                      | 4.1                  | 1020.0             | 0                   |
|          | 700  | 11                  | 341                      | 0.7                  | 1022.9             | 0                   |
|          | 1300 | 6                   | 344                      | 3.6                  | 1022.0             | 0                   |
|          | 1900 | 4                   | 325                      | 4.0                  | 1022.8             | 0                   |
| 9        | 100  | 5                   | 30                       | 4.7                  | 1020.4             | 0                   |
|          | 700  | 8                   | 79                       | 4.5                  | 1015.6             | 0                   |
|          | 1300 | 11                  | 87                       | 7.2                  | 1004.3             | 0                   |
|          | 1900 | 5                   | 289                      | 7.2                  | 1000.1             | 0                   |
| 10       | 100  | 7                   | 220                      | 7.6                  | 999.1              | 0                   |
|          | 700  | 10                  | 266                      | 5.6                  | 1001.3             | 0                   |
|          | 1300 | 10                  | 248                      | 6.5                  | 1004.1             | 0                   |
|          | 1900 | 8                   | 221                      | 6.5                  | 1006.2             | 0                   |

**Table 3**  
**Meteorological Data (continued)**

| Day | Hour | Jan 1997            |                          |                      |                    |                     |
|-----|------|---------------------|--------------------------|----------------------|--------------------|---------------------|
|     |      | Wind Speed<br>m/sec | Wind Direction<br>deg TN | Temperature<br>deg C | Atm Pressure<br>mb | Precipitation<br>mm |
| 11  | 100  | 9                   | 210                      | 7.4                  | 1003.6             | 0                   |
|     | 700  | 10                  | 285                      | 0.2                  | 1009.6             | 0                   |
|     | 1300 | 6                   | 280                      | 1.6                  | 1012.9             | 0                   |
|     | 1900 | 5                   | 1                        | 0.0                  | 1017.9             | 0                   |
| 12  | 100  | 5                   | 1                        | -1.1                 | 1020.2             | 0                   |
|     | 700  | 6                   | 309                      | -3.5                 | 1023.3             | 0                   |
|     | 1300 | 3                   | 355                      | 0.6                  | 1023.9             | 0                   |
|     | 1900 | 4                   | 1                        | 1.5                  | 1025.5             | 0                   |
| 13  | 100  | 6                   | 308                      | -0.4                 | 1026.0             | 0                   |
|     | 700  | 7                   | 1                        | -1.2                 | 1028.6             | 0                   |
|     | 1300 | 5                   | 352                      | 0.2                  | 1028.5             | 0                   |
|     | 1900 | 6                   | 313                      | -0.2                 | 1029.4             | 0                   |
| 14  | 100  | 3                   | 305                      | -2.0                 | 1028.5             | 0                   |
|     | 700  | 4                   | 317                      | -2.8                 | 1029.3             | 0                   |
|     | 1300 | 3                   | 6                        | 1.8                  | 1028.9             | 0                   |
|     | 1900 | 0                   |                          | -1.4                 | 1029.2             | 0                   |
| 15  | 100  | 7                   | 6                        | 2.7                  | 1028.6             | 0                   |
|     | 700  | 3                   | 328                      | -1.2                 | 1028.4             | 0                   |
|     | 1300 | 2                   | 85                       | 4.6                  | 1026.1             | 0                   |
|     | 1900 | 4                   | 131                      | 5.3                  | 1020.8             | 0                   |
| 16  | 100  | 11                  | 180                      | 12.3                 | 1014.6             | 0                   |
|     | 700  | 16                  | 183                      | 14.9                 | 1003.7             | 0                   |
|     | 1300 | 7                   | 259                      | 12.2                 | 1001.2             | 0                   |
|     | 1900 | 10                  | 303                      | 7.7                  | 1005.5             | 0                   |
| 17  | 100  | 12                  | 1                        | 0.0                  | 1011.6             | 0                   |
|     | 700  | 11                  | 305                      | -5.4                 | 1018.8             | 17                  |
|     | 1300 | 4                   | 279                      | -3.8                 | 1020.1             | 0                   |
|     | 1900 | 6                   | 283                      | -4.4                 | 1020.3             | 0                   |
| 18  | 100  | 7                   | 1                        | -3.9                 | 1017.5             | 0                   |
|     | 700  | 8                   | 1                        | -7.3                 | 1017.0             | 0                   |
|     | 1300 | 8                   | 1                        | -4.3                 | 1014.4             | 0                   |
|     | 1900 | 10                  | 307                      | -4.8                 | 1019.5             | 0                   |
| 19  | 100  | 12                  | 327                      | -9.8                 | 1023.6             | 0                   |
|     | 700  | 7                   | 315                      | -9.8                 | 1024.3             | 0                   |
|     | 1300 | 1                   | 343                      | -6.2                 | 1024.5             | 0                   |
|     | 1900 | 3                   | 192                      | -6.7                 | 1022.5             | 0                   |
| 20  | 100  | 4                   | 204                      | -3.4                 | 1020.0             | 0                   |
|     | 700  | 4                   | 205                      | -2.2                 | 1018.7             | 0                   |
|     | 1300 | 6                   | 251                      | 3.1                  | 1016.2             | 0                   |
|     | 1900 | 5                   | 243                      | 2.4                  | 1017.0             | 0                   |

**Table 3**  
**Meteorological Data (concluded)**

| Jan 1997      |      |      |                |                     |       |                |   |
|---------------|------|------|----------------|---------------------|-------|----------------|---|
| Precipitation | Wind |      | Wind           | Temperature         | Atm   |                |   |
|               | Day  | Hour | Speed<br>m/sec | Direction<br>deg TN | deg C | Pressure<br>mb |   |
|               |      |      |                |                     |       | mm             |   |
| 21            | 100  | 4    | 262            |                     | 1.7   | 1020.1         | 0 |
|               | 700  | 11   |                | 6                   | 3.6   | 1027.2         | 0 |
|               | 1300 | 6    |                | 13                  | 4.4   | 1031.1         | 0 |
|               | 1900 | 3    |                | 92                  | 3.4   | 1032.9         | 0 |
| 22            | 100  | 0    |                |                     | -0.4  | 1031.3         | 0 |
|               | 700  | 5    | 166            |                     | 5.5   | 1028.2         | 0 |
|               | 1300 | 11   |                | 186                 | 16.1  | 1022.9         | 0 |
|               | 1900 | 9    |                | 192                 | 11.5  | 1019.6         | 0 |
| 23            | 100  | 8    | 217            |                     | 10.8  | 1015.0         | 0 |
|               | 700  | 4    | 236            |                     | 8.7   | 1016.0         | 6 |
|               | 1300 | 4    | 245            |                     | 13.8  | 1018.5         | 0 |
|               | 1900 | 3    | 248            |                     | 9.5   | 1022.0         | 0 |
| 24            | 100  | 10   | 15             |                     | 6.3   | 1025.9         | 0 |
|               | 700  | 5    | 46             |                     | 6.4   | 1027.2         | 0 |
|               | 1300 | 7    | 110            |                     | 8.8   | 1024.1         | 0 |
|               | 1900 | 7    | 154            |                     | 8.3   | 1020.2         | 0 |
| 25            | 100  | 9    | 198            |                     | 12.2  | 1014.6         | 0 |
|               | 700  | 7    | 253            |                     | 11.7  | 1014.8         | 4 |
|               | 1300 | 9    | 212            |                     | 12.6  | 1012.2         | 0 |
|               | 1900 | 7    | 1              |                     | 11.3  | 1016.2         | 0 |
| 26            | 100  | 6    | 1              |                     | 6.2   | 1020.2         | 0 |
|               | 700  | 5    | 307            |                     | 2.7   | 1027.7         | 3 |
|               | 1300 | 8    | 11             |                     | 3.6   | 1030.9         | 0 |
|               | 1900 | 3    | 48             |                     | 3.0   | 1033.1         | 0 |
| 27            | 100  | 4    | 74             |                     | 3.3   | 1035.2         | 0 |
|               | 700  | 5    | 85             |                     | 4.3   | 1036.1         | 0 |
|               | 1300 | 5    | 106            |                     | 6.7   | 1033.1         | 0 |
|               | 1900 | 8    | 143            |                     | 7.1   | 1030.2         | 0 |
| 28            | 100  | 10   | 180            |                     | 12.2  | 1024.4         | 0 |
|               | 700  | 7    | 195            |                     | 10.8  | 1020.8         | 0 |
|               | 1300 | 8    | 212            |                     | 15.5  | 1015.6         | 0 |
|               | 1900 | 12   | 11             |                     | 5.9   | 1023.9         | 0 |
| 29            | 100  | 13   | 13             |                     | 4.4   | 1027.8         | 0 |
|               | 700  | 10   | 17             |                     | 3.1   | 1031.5         | 5 |
|               | 1300 | 8    | 17             |                     | 3.0   | 1032.7         | 0 |
|               | 1900 | 7    | 53             |                     | 2.0   | 1032.3         | 0 |
| 30            | 100  | 7    | 60             |                     | 3.8   | 1030.1         | 0 |
|               | 700  | 7    | 54             |                     | 5.3   | 1027.1         | 0 |
|               | 1300 | 9    | 26             |                     | 6.2   | 1022.6         | 0 |
|               | 1900 | 8    | 18             |                     | 6.3   | 1018.6         | 0 |
| 31            | 100  | 8    | 348            |                     | 5.3   | 1016.0         | 0 |
|               | 700  | 6    | 328            |                     | 3.7   | 1016.4         | 0 |
|               | 1300 | 3    | 252            |                     | 5.5   | 1014.3         | 0 |
|               | 1900 | 3    | 214            |                     | 6.0   | 1012.6         | 0 |
|               |      |      | Resultant      |                     | Mean  | Mean           |   |

# Wave Data

## 3

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Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4**  
**Wave Data**

| Day | Hour | Jan 1997           |        |                  |        |                    |        |        |               |        |  |
|-----|------|--------------------|--------|------------------|--------|--------------------|--------|--------|---------------|--------|--|
|     |      | 641 Pressure Gauge |        | 625 Baylor Gauge |        | 3111 8 Meter Array |        |        | 630 Waverider |        |  |
|     |      | Hmo,m              | Tp,sec | Hmo,m            | Tp,sec | Hmo,m              | Tp,sec | Dir,TN | Hmo,m         | Tp,sec |  |
| 1   | 0100 | 1.52               | 7.4    | 2.07             | 7.2    | 2.25               | 7.1    | 64     | 2.62          | 6.7    |  |
|     | 0700 | 1.03               | 7.2    | 1.48             | 7.6    | 1.38               | 7.6    | 56     | 1.76          | 7.7    |  |
|     | 1300 | 0.93               | 8.3    | 1.20             | 8.6    | 1.25               | 8.9    | 56     | 1.54          | 8.4    |  |
|     | 1900 | 0.71               | 8.6    | 1.19             | 8.1    | 1.22               | 8.2    | 58     | 1.46          | 7.7    |  |
| 2   | 0100 | 0.60               | 7.6    | 1.03             | 9.9    | 1.06               | 9.8    | 68     | 1.51          | 8.4    |  |
|     | 0700 | 0.46               | 9.9    | 0.90             | 9.9    | 0.94               | 9.8    | 70     | 1.51          | 8.4    |  |
|     | 1300 | 0.35               | 9.5    | 0.67             | 9.5    | 0.73               | 8.9    | 68     | 0.87          | 8.4    |  |
|     | 1900 | 0.27               | 9.9    | 0.57             | 9.9    | 0.63               | 10.8   | 74     | 0.74          | 9.1    |  |
| 3   | 0100 | 0.26               | 10.3   | 0.46             | 10.3   | 0.49               | 9.8    | 76     | 0.62          | 10.1   |  |
|     | 0700 | 0.18               | 9.2    | 0.35             | 9.2    | 0.37               | 8.9    | 78     | 0.46          | 9.1    |  |
|     | 1300 | 0.18               | 9.5    | 0.29             | 9.5    | 0.31               | 9.8    | 82     | 0.40          | 9.1    |  |
|     | 1900 | 0.14               | 11.7   | 0.25             | 9.9    | 0.26               | 9.8    | 84     | 0.30          | 11.2   |  |
| 4   | 0100 | 0.15               | 9.5    | 0.22             | 10.3   | 0.23               | 9.8    | 108    | 0.29          | 10.6   |  |
|     | 0700 | 0.14               | 9.2    | 0.22             | 9.2    | 0.23               | 9.8    | 102    | 0.27          | 10.6   |  |
|     | 1300 | 0.15               | 8.3    | 0.23             | 8.1    | 0.25               | 8.9    | 96     | 0.28          | 7.7    |  |
|     | 1900 | 0.14               | 9.2    | 0.25             | 9.2    | 0.23               | 8.9    | 106    | 0.28          | 9.1    |  |
| 5   | 0100 | 0.16               | 8.9    | 0.27             | 9.5    | 0.25               | 8.9    | 108    | 0.30          | 9.1    |  |
|     | 0700 | 0.17               | 8.6    | 0.32             | 8.9    | 0.25               | 8.9    | 104    | 0.39          | 8.4    |  |
|     | 1300 | 0.21               | 8.9    | 0.35             | 8.9    | 0.28               | 8.9    | 108    | 0.52          | 3.9    |  |
|     | 1900 | 0.24               | 7.4    | 0.39             | 4.1    | 0.32               | 8.2    | 108    | 0.64          | 4.6    |  |
| 6   | 0100 | 0.21               | 8.1    | 0.28             | 8.1    | 0.31               | 8.2    | 110    | 0.43          | 7.7    |  |
|     | 0700 | 0.18               | 13.5   | 0.27             | 13.5   | 0.27               | 13.6   | 62     | 0.37          | 8.4    |  |
|     | 1300 | 0.16               | 12.9   | 0.26             | 13.5   | 0.26               | 13.6   | 68     | 0.40          | 14.3   |  |
|     | 1900 | 0.16               | 12.9   | 0.24             | 12.9   | 0.25               | 13.6   | 46     | 0.28          | 13.4   |  |
| 7   | 0100 | 0.13               | 12.9   | 0.21             | 12.2   | 0.24               | 12.0   | 66     | 0.27          | 12.6   |  |
|     | 0700 | 0.15               | 12.2   | 0.24             | 12.2   | 0.21               | 12.0   | 68     | 0.35          | 12.6   |  |
|     | 1300 | 0.19               | 4.0    | 0.30             | 11.7   | 0.31               | 4.2    | 46     | 0.49          | 3.8    |  |
|     | 1900 | 0.37               | 5.0    | 0.48             | 4.1    | 0.52               | 4.8    | 50     | 0.68          | 3.6    |  |
| 8   | 0100 | 0.57               | 5.3    | 0.83             | 6.0    | 1.02               | 5.3    | 46     | 1.06          | 6.7    |  |
|     | 0700 | 1.30               | 7.0    | 1.26             | 6.5    | 1.24               | 6.2    | 46     | 1.87          | 6.7    |  |
|     | 1300 | 0.81               | 5.9    | 0.95             | 6.5    | 0.92               | 6.2    | 44     | 1.20          | 5.9    |  |
|     | 1900 | 0.61               | 5.6    | 0.64             | 5.9    | 0.67               | 5.9    | 42     | 0.85          | 6.3    |  |
| 9   | 0100 | 0.36               | 5.6    | 0.50             | 6.8    | 0.54               | 6.6    | 54     | 0.74          | 7.2    |  |
|     | 0700 | 0.52               | 5.3    | 0.69             | 5.2    | 0.71               | 4.1    | 44     | 0.84          | 5.6    |  |
|     | 1300 | 0.89               | 6.8    | 1.54             | 5.9    | 1.55               | 6.2    | 46     | 1.97          | 5.6    |  |
|     | 1900 | 0.95               | 6.8    | 1.42             | 6.6    | 1.36               | 7.1    | 64     | 1.66          | 6.7    |  |
| 10  | 0100 | 0.42               | 9.2    | 0.77             | 9.2    | 0.85               | 8.9    | 82     | 1.08          | 10.1   |  |
|     | 0700 | 0.35               | 9.2    | 0.45             | 8.9    | 0.48               | 8.9    | 110    | 0.92          | 10.1   |  |
|     | 1300 | 0.16               | 9.2    | 0.32             | 9.5    | 0.31               | 8.9    | 110    | 0.92          | 10.0   |  |
|     | 1900 | 0.26               | 8.6    | 0.34             | 8.6    | 0.36               | 8.2    | 108    | 0.55          | 8.4    |  |

**Table 4**  
**Wave Data (continued)**

| Jan 1997 |      |                         |        |                       |        |                        |        |        |                    |        |
|----------|------|-------------------------|--------|-----------------------|--------|------------------------|--------|--------|--------------------|--------|
| Day      | Hour | 641                     |        | 625                   |        | 3111                   |        |        | 630                |        |
|          |      | Pressure Gauge<br>Hmo,m | Tp,sec | Baylor Gauge<br>Hmo,m | Tp,sec | 8 Meter Array<br>Hmo,m | Tp,sec | Dir,TN | Waverider<br>Hmo,m | Tp,sec |
| 11       | 0100 | 0.15                    | 7.6    | 0.30                  | 9.9    | 0.24                   | 8.9    | 90     | 0.51               | 9.1    |
|          | 0700 | 0.20                    | 7.8    | 0.31                  | 4.0    | 0.32                   | 7.6    | 108    | 0.91               | 4.3    |
|          | 1300 | 0.26                    | 5.5    | 0.35                  | 9.9    | 0.35                   | 8.9    | 104    | 0.80               | 4.2    |
|          | 1900 | 0.32                    | 4.5    | 0.46                  | 8.3    | 0.45                   | 7.1    | 50     | 0.69               | 4.4    |
| 12       | 0100 | 0.23                    | 5.4    | 0.37                  | 9.2    | 0.34                   | 13.6   | 90     | 0.68               | 4.1    |
|          | 0700 | 0.25                    | 13.5   | 0.42                  | 12.9   | 0.34                   | 13.6   | 104    | 0.63               | 3.8    |
|          | 1300 | 0.27                    | 4.4    | 0.39                  | 4.4    | 0.35                   | 4.4    | 14     | 0.62               | 4.4    |
|          | 1900 | 0.25                    | 4.4    | 0.33                  | 4.3    | 0.34                   | 4.2    | 40     | 0.46               | 4.2    |
| 13       | 0100 | 0.35                    | 4.4    | 0.49                  | 3.9    | 0.47                   | 4.2    | 28     | 0.62               | 5.3    |
|          | 0700 | 0.80                    | 5.1    | 0.95                  | 4.9    | 1.13                   | 5.3    | 34     | 1.22               | 4.8    |
|          | 1300 | 0.84                    | 6.1    | 0.87                  | 6.0    | 0.89                   | 6.2    | 44     | 1.38               | 6.3    |
|          | 1900 | 0.53                    | 5.6    | 0.62                  | 5.5    | 0.62                   | 5.6    | 44     | 1.06               | 5.3    |
| 14       | 0100 | 0.55                    | 5.3    | 0.63                  | 5.5    | 0.64                   | 5.3    | 32     | 0.81               | 5.1    |
|          | 0700 | 0.69                    | 5.6    | 0.76                  | 5.5    | 0.82                   | 5.9    | 48     | 0.94               | 5.3    |
|          | 1300 | 0.67                    | 5.7    | 0.67                  | 5.9    | 0.67                   | 6.2    | 32     | 0.80               | 5.9    |
|          | 1900 | 0.49                    | 5.6    | 0.60                  | 5.7    | 0.61                   | 5.6    | 48     | 0.64               | 5.1    |
| 15       | 0100 | 0.64                    | 5.1    | 0.77                  | 5.2    | 0.75                   | 5.0    | 40     | 0.84               | 4.8    |
|          | 0700 | 0.42                    | 4.7    | 0.60                  | 4.7    | 0.59                   | 5.6    | 52     | 0.71               | 4.8    |
|          | 1300 | 0.38                    | 4.8    | 0.48                  | 4.9    | 0.45                   | 5.0    | 56     | 0.58               | 5.1    |
|          | 1900 | 0.23                    | 5.4    | 0.43                  | 5.7    | 0.35                   | 5.9    | 60     | 0.51               | 5.6    |
| 16       | 0100 | 0.29                    | 3.8    | 0.51                  | 3.7    | 0.44                   | 3.9    | 92     | 0.63               | 3.5    |
|          | 0700 | 0.68                    | 6.8    | 1.00                  | 6.8    | 0.94                   | 7.1    | 110    | 1.55               | 6.3    |
|          | 1300 | 0.66                    | 8.9    | 0.90                  | 9.2    | 0.93                   | 8.9    | 108    | 1.17               | 9.1    |
|          | 1900 | 0.40                    | 9.9    | 0.73                  | 10.3   | 0.65                   | 9.8    | 106    | 0.95               | 10.1   |
| 17       | 0100 | 0.67                    | 5.1    | 0.94                  | 4.9    | 0.93                   | 5.0    | 20     | 1.10               | 10.1   |
|          | 0700 | 0.94                    | 6.1    | 1.04                  | 6.8    | 1.00                   | 7.1    | 50     | 1.39               | 6.3    |
|          | 1300 | 0.73                    | 6.5    | 0.81                  | 6.5    | 0.77                   | 6.6    | 46     | 1.07               | 6.7    |
|          | 1900 | 0.46                    | 5.9    | 0.56                  | 6.0    | 0.58                   | 6.6    | 40     | 0.81               | 6.3    |
| 18       | 0100 | 0.30                    | 5.5    | 0.36                  | 9.2    | 0.38                   | 8.2    | 60     | 0.64               | 9.1    |
|          | 0700 | 0.37                    | 4.5    | 0.59                  | 4.7    | 0.57                   | 4.6    | 8      | 0.83               | 4.6    |
|          | 1300 | 0.31                    | 4.6    | 0.48                  | 4.2    | 0.44                   | 4.1    | 6      | 0.79               | 4.6    |
|          | 1900 | 0.47                    | 5.5    | 0.63                  | 4.7    | 0.74                   | 4.8    | 12     | 1.09               | 4.6    |
| 19       | 0100 | 1.20                    | 6.5    | 1.29                  | 6.5    | 1.33                   | 6.2    | 44     | 1.75               | 6.3    |
|          | 0700 | 0.99                    | 6.3    | 1.06                  | 6.6    | 0.97                   | 6.2    | 34     | 1.32               | 6.7    |
|          | 1300 | 0.66                    | 5.9    | 0.81                  | 6.0    | 0.81                   | 5.9    | 52     | 0.95               | 6.3    |
|          | 1900 | 0.45                    | 7.2    | 0.61                  | 7.8    | 0.59                   | 7.6    | 62     | 0.74               | 7.7    |
| 20       | 0100 | 0.25                    | 13.5   | 0.49                  | 7.2    | 0.53                   | 7.1    | 58     | 0.61               | 6.7    |
|          | 0700 | 0.21                    | 12.9   | 0.30                  | 14.2   | 0.38                   | 12.0   | 54     | 0.47               | 13.4   |
|          | 1300 | 0.17                    | 12.2   | 0.32                  | 11.1   | 0.39                   | 10.8   | 60     | 0.41               | 11.2   |
|          | 1900 | 0.19                    | 12.2   | 0.19                  | 11.7   | 0.40                   | 12.0   | 90     | 0.41               | 11.2   |

**Table 4**  
**Wave Data (concluded)**

| Jan 1997 |      |                |              |              |              |              |      |        |               |              |  |              |  |
|----------|------|----------------|--------------|--------------|--------------|--------------|------|--------|---------------|--------------|--|--------------|--|
| Day      | Hour | 641            |              | 625          |              | 3111         |      |        | 8 Meter Array |              |  | 630          |  |
|          |      | Pressure Gauge | Hmo,m Tp,sec | Baylor Gauge | Hmo,m Tp,sec | Hmo,m Tp,sec |      | Dir,TN | Waverider     | Hmo,m Tp,sec |  | Hmo,m Tp,sec |  |
| 21       | 0100 | 0.17           | 11.7         | 0.21         | 11.7         | 0.45         | 12.0 | 64     | 0.42          | 11.2         |  |              |  |
|          | 0700 | 0.78           | 4.3          | 1.12         | 4.5          | 1.11         | 4.6  | 26     | 1.17          | 4.1          |  |              |  |
|          | 1300 | 0.94           | 5.9          | 1.24         | 6.3          | 1.27         | 6.6  | 48     | 1.55          | 6.3          |  |              |  |
|          | 1900 | 0.68           | 5.9          | 0.87         | 6.8          | 0.85         | 7.1  | 58     | 1.12          | 5.6          |  |              |  |
| 22       | 0100 | 0.43           | 4.8          | 0.68         | 7.2          | 0.67         | 7.1  | 54     | 0.88          | 7.2          |  |              |  |
|          | 0700 | 0.40           | 5.6          | 0.60         | 7.0          | 0.59         | 6.6  | 58     | 0.72          | 7.2          |  |              |  |
|          | 1300 | 0.27           | 9.2          | 0.62         | 6.5          | 0.61         | 8.9  | 88     | 0.83          | 6.7          |  |              |  |
|          | 1900 | 0.48           | 6.5          | 0.75         | 5.9          | 0.83         | 7.1  | 88     | 1.14          | 6.7          |  |              |  |
| 23       | 0100 | 0.47           | 7.6          | 0.76         | 7.4          | 0.81         | 7.6  | 108    | 1.12          | 7.2          |  |              |  |
|          | 0700 | 0.55           | 8.6          | 0.77         | 8.6          | 0.78         | 8.9  | 86     | 0.95          | 8.4          |  |              |  |
|          | 1300 | 0.31           | 8.9          | 0.50         | 8.6          | 0.55         | 8.2  | 106    | 0.70          | 8.4          |  |              |  |
|          | 1900 | 0.31           | 9.2          | 0.44         | 8.9          | 0.49         | 8.9  | 98     | 0.64          | 8.4          |  |              |  |
| 24       | 0100 | 0.84           | 4.7          | 1.10         | 4.5          | 1.17         | 5.0  | 44     | 1.28          | 4.6          |  |              |  |
|          | 0700 | 0.89           | 6.0          | 1.09         | 6.0          | 1.01         | 5.9  | 32     | 1.33          | 5.9          |  |              |  |
|          | 1300 | 0.51           | 5.5          | 0.81         | 5.6          | 0.78         | 5.3  | 40     | 0.97          | 5.6          |  |              |  |
|          | 1900 | 0.72           | 5.7          | 0.84         | 5.6          | 0.87         | 6.2  | 52     | 1.11          | 5.6          |  |              |  |
| 25       | 0100 | 0.84           | 7.2          | 1.31         | 7.6          | 1.48         | 8.2  | 58     | 1.80          | 7.7          |  |              |  |
|          | 0700 | 0.98           | 8.6          | 1.43         | 8.3          | 1.53         | 8.2  | 68     | 2.01          | 8.4          |  |              |  |
|          | 1300 | 0.55           | 7.8          | 1.03         | 8.1          | 1.03         | 8.9  | 76     | 1.35          | 7.7          |  |              |  |
|          | 1900 | 0.44           | 8.9          | 0.75         | 8.3          | 0.77         | 8.9  | 72     | 0.98          | 8.4          |  |              |  |
| 26       | 0100 | 0.28           | 8.3          | 0.49         | 8.3          | 0.44         | 8.2  | 58     | 0.70          | 8.4          |  |              |  |
|          | 0700 | 0.27           | 8.9          | 0.41         | 7.8          | 0.44         | 8.2  | 108    | 0.60          | 9.1          |  |              |  |
|          | 1300 | 0.80           | 6.3          | 1.00         | 6.8          | 0.94         | 6.2  | 48     | 1.20          | 5.9          |  |              |  |
|          | 1900 | 0.70           | 6.5          | 0.76         | 6.3          | 0.74         | 6.2  | 42     | 1.01          | 6.3          |  |              |  |
| 27       | 0100 | 0.45           | 5.4          | 0.62         | 5.4          | 0.60         | 5.6  | 38     | 0.71          | 10.1         |  |              |  |
|          | 0700 | 0.41           | 4.9          | 0.61         | 4.6          | 0.54         | 10.8 | 88     | 0.70          | 5.1          |  |              |  |
|          | 1300 | 0.38           | 4.0          | 0.72         | 3.9          | 0.65         | 4.1  | 108    | 0.89          | 4.1          |  |              |  |
|          | 1900 | 0.46           | 4.7          | 0.88         | 4.4          | 0.82         | 4.8  | 58     | 1.08          | 4.6          |  |              |  |
| 28       | 0100 | 0.37           | 5.1          | 0.78         | 4.7          | 0.69         | 5.0  | 56     | 0.91          | 5.1          |  |              |  |
|          | 0700 | 0.55           | 6.0          | 0.85         | 6.6          | 0.97         | 6.6  | 106    | 1.13          | 5.6          |  |              |  |
|          | 1300 | 0.50           | 7.2          | 0.76         | 7.0          | 0.78         | 7.1  | 108    | 1.05          | 7.7          |  |              |  |
|          | 1900 | 1.05           | 5.2          | 1.37         | 5.2          | 1.54         | 5.9  | 32     | 1.67          | 5.3          |  |              |  |
| 29       | 0100 | 1.27           | 5.9          | 1.52         | 5.7          | 1.58         | 6.2  | 50     | 1.90          | 5.9          |  |              |  |
|          | 0700 | 0.98           | 5.9          | 1.28         | 6.0          | 1.16         | 6.2  | 56     | 1.55          | 5.9          |  |              |  |
|          | 1300 | 0.67           | 5.4          | 0.97         | 5.4          | 0.91         | 5.3  | 56     | 1.21          | 5.1          |  |              |  |
|          | 1900 | 0.67           | 5.7          | 1.00         | 6.5          | 0.93         | 5.9  | 36     | 1.15          | 6.7          |  |              |  |
| 30       | 0100 | 0.66           | 5.5          | 0.98         | 4.2          | 0.90         | 5.3  | 52     | 1.14          | 4.6          |  |              |  |
|          | 0700 | 0.66           | 4.5          | 1.04         | 4.7          | 0.97         | 4.6  | 80     | 1.22          | 4.8          |  |              |  |
|          | 1300 | 0.78           | 5.0          | 1.17         | 5.5          | 1.18         | 5.3  | 68     | 1.32          | 5.1          |  |              |  |
|          | 1900 | 0.85           | 5.5          | 1.39         | 5.7          | 1.28         | 5.9  | 72     | 1.62          | 5.6          |  |              |  |
| 31       | 0100 | 0.88           | 5.5          | 1.26         | 6.3          | 1.30         | 8.2  | 86     | 1.50          | 5.6          |  |              |  |
|          | 0700 | 0.97           | 6.0          | 1.40         | 8.6          | 1.51         | 8.9  | 80     | 1.69          | 8.4          |  |              |  |
|          | 1300 | 1.09           | 11.2         | 1.59         | 10.7         | 1.67         | 10.8 | 90     | 1.76          | 11.2         |  |              |  |
|          | 1900 | 0.79           | 9.5          | 1.21         | 9.9          | 1.27         | 9.8  | 74     | 1.50          | 10.1         |  |              |  |
| Mean     |      | 0.51           | 7.3          | 0.73         | 7.4          | 0.74         | 7.6  | 66     | 0.96          | 7.1          |  |              |  |
| Std dev  |      | 0.30           | 2.5          | 0.38         | 2.4          | 0.39         | 2.4  | 26     | 0.46          | 2.4          |  |              |  |

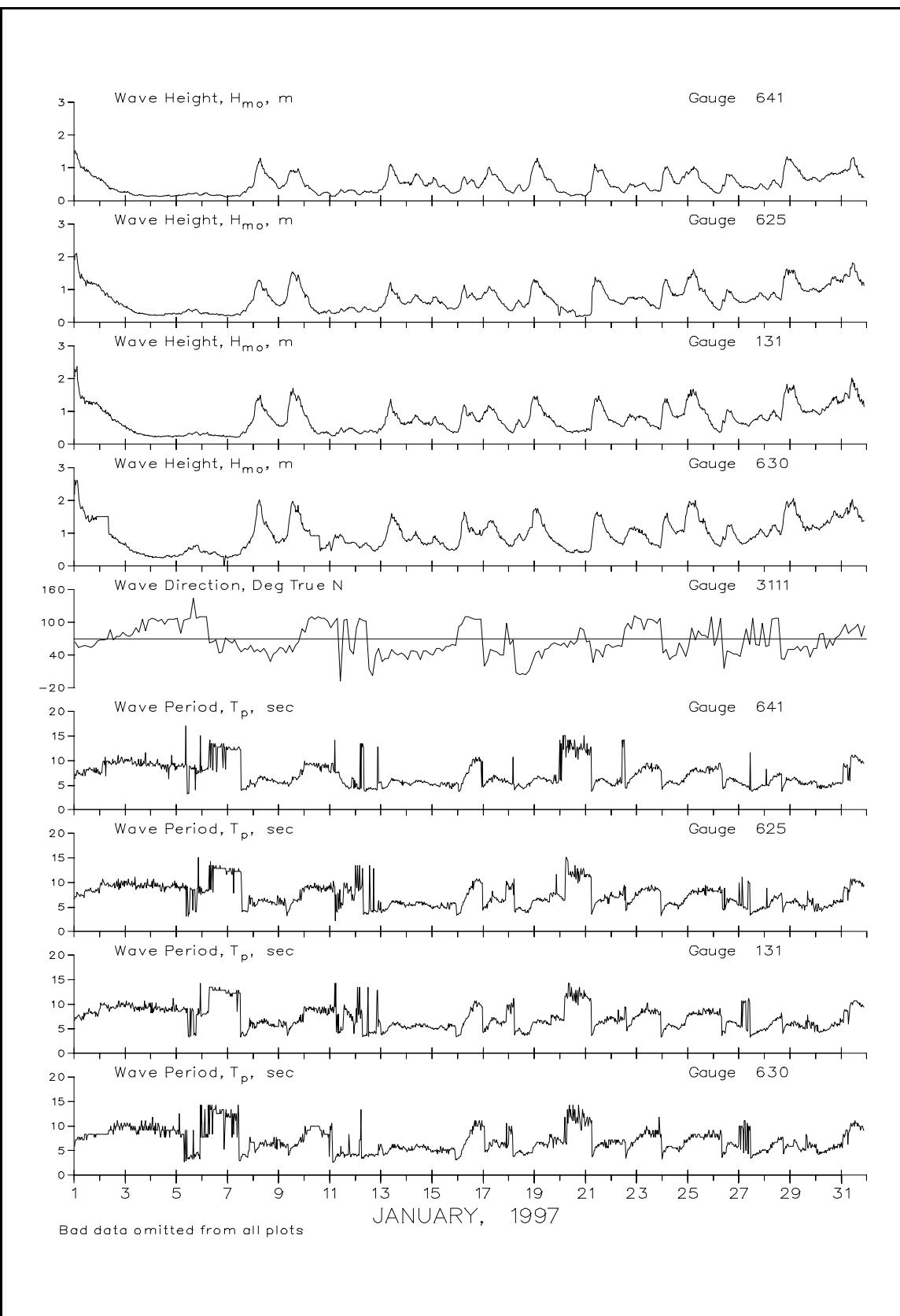


Figure 5. Wave Heights and Periods

# Current Data

## 4

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Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

| JANUARY 1997 |      |             |       |       |       |      |      |       |       |       |     |     |      |       |       |       |     |
|--------------|------|-------------|-------|-------|-------|------|------|-------|-------|-------|-----|-----|------|-------|-------|-------|-----|
|              |      | Cross       | Long  |       | Cross | Long |      | Cross | Long  |       |     |     |      |       |       |       |     |
| Day          | Time | Shore       | Shore | Speed | Dir   | Day  | Time | Shore | Shore | Speed | Dir | Day | Time | Shore | Shore | Speed | Dir |
| 1            | 100  |             |       |       |       | 1300 |      |       |       |       |     | 22  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 12   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 2            | 100  | Gauge       |       |       |       | 1300 |      |       |       |       |     | 23  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 13   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 3            | 100  | inoperative |       |       |       | 1300 |      |       |       |       |     | 24  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 14   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 4            | 100  | all         |       |       |       | 1300 |      |       |       |       |     | 25  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 15   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 5            | 100  | month.      |       |       |       | 1300 |      |       |       |       |     | 26  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 16   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 6            | 100  |             |       |       |       | 1300 |      |       |       |       |     | 27  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 17   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 7            | 100  |             |       |       |       | 1300 |      |       |       |       |     | 28  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 18   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 8            | 100  |             |       |       |       | 1300 |      |       |       |       |     | 29  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 19   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 9            | 100  |             |       |       |       | 1300 |      |       |       |       |     | 30  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 20   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 10           | 100  |             |       |       |       | 1300 |      |       |       |       |     | 31  | 100  |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     | 700  |       |       |       |     |
|              | 1300 |             |       |       |       | 21   | 100  |       |       |       |     |     | 1300 |       |       |       |     |
|              | 1900 |             |       |       |       | 700  |      |       |       |       |     |     | 1900 |       |       |       |     |
| 11           | 100  |             |       |       |       | 1300 |      |       |       |       |     |     | 1900 |       |       |       |     |
|              | 700  |             |       |       |       | 1900 |      |       |       |       |     |     |      |       |       |       |     |

KEY:

- +cross-shore = offshore, cm/sec
- cross-shore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

| Jan 1997 |                |               |       |     |                |               |       |     |                |       |     |  |
|----------|----------------|---------------|-------|-----|----------------|---------------|-------|-----|----------------|-------|-----|--|
| Day      | Pier End       |               |       |     | Mid-Surf Zone  |               |       |     | Beach          |       |     |  |
|          | Cross<br>Shore | Long<br>Shore | Speed | Dir | Cross<br>Shore | Long<br>Shore | Speed | Dir | Location       | Speed | Dir |  |
| 1        | 0              | 55            | 55    | 160 | -13            | 87            | 88    | 169 | North          | 9     | S   |  |
| 2        | 6              | 20            | 21    | 143 | 23             | 23            | 33    | 115 | North          | 8     | S   |  |
| 3        | 11             | -15           | 19    | 17  | 0              | -61           | 61    | 340 | South          | 7     | N   |  |
| 4        | 6              | 20            | 21    | 70  | -9             | -30           | 32    | 323 | South          | 4     | N   |  |
| 5        | 17             | -17           | 25    | 25  | -3             | -30           | 31    | 334 | South          | 3     | N   |  |
| 6        | 10             | 10            | 14    | 115 | 0              | -23           | 23    | 340 | South          | 9     | N   |  |
| 7        | 5              | 23            | 23    | 149 | 7              | 8             | 11    | 118 | North          | 25    | S   |  |
| 8        | 0              | 102           | 102   | 160 | 0              | 68            | 68    | 160 | North          | 9     | S   |  |
| 9        | -11            | 22            | 24    | 187 | 0              | 25            | 25    | 160 | North          | 4     | S   |  |
| 10       | 25             | 20            | 33    | 70  | 9              | -18           | 21    | 7   | South          | 3     | N   |  |
| 11       | 25             | 25            | 36    | 70  | 9              | 23            | 25    | 138 | North          | 9     | S   |  |
| 12       | 0              | 18            | 18    | 160 | 3              | 20            | 21    | 151 | North          | 10    | S   |  |
| 13       | -3             | 29            | 29    | 166 | 0              | 68            | 68    | 160 | North          | 73    | S   |  |
| 14       | -2             | 44            | 44    | 163 | -1             | 23            | 23    | 163 | North          | 20    | S   |  |
| 15       | -3             | 27            | 27    | 166 | -12            | 47            | 48    | 174 | North          | 14    | S   |  |
| 16       | 0              | -76           | 76    | 340 | 0              | -152          | 152   | 340 | South          | 58    | N   |  |
| 17       | 20             | 44            | 48    | 136 | 12             | 122           | 123   | 154 | North          | 52    | S   |  |
| 18       | 19             | 17            | 25    | 112 | 4              | 28            | 28    | 151 | North          | 7     | S   |  |
| 19       | 0              | 55            | 55    | 160 | 0              | 76            | 76    | 160 | no observation |       |     |  |
| 20       | 11             | -9            | 14    | 31  | 47             | 23            | 52    | 70  | North          | 5     | S   |  |
| 21       | -4             | 41            | 41    | 166 | 13             | 87            | 88    | 151 | North          | 55    | S   |  |
| 22       | 1              | -6            | 6     | 351 | 4              | 14            | 14    | 70  | South          | 12    | S   |  |
| 23       | 11             | -4            | 12    | 49  | 9              | -25           | 27    | 359 | South          | 30    | N   |  |
| 24       | 9              | 17            | 19    | 70  | 6              | 28            | 28    | 149 | North          | 3     | S   |  |
| 25       | 3              | -11           | 12    | 357 | -3             | -61           | 61    | 337 | South          | 40    | N   |  |
| 26       | 0              | 44            | 44    | 160 | 3              | 32            | 32    | 154 | North          | 22    | S   |  |
| 27       | -11            | -15           | 18    | 303 | -7             | -12           | 14    | 309 | South          | 12    | N   |  |
| 28       | 7              | -34           | 35    | 351 | -17            | -87           | 89    | 329 | South          | 58    | N   |  |
| 29       | -12            | 61            | 62    | 171 | -12            | 122           | 123   | 166 | North          | 82    | S   |  |
| 30       | -3             | 6             | 6     | 189 | -6             | 12            | 14    | 187 | North          | 27    | N   |  |
| 31       | 15             | 61            | 63    | 146 | 2              | 7             | 8     | 70  | North          | 17    | N   |  |

KEY:

- +cross-shore = offshore, cm/sec
- cross-shore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

# Visual Observations

## 5

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Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

|     |      |                                      |                   |                      | Jan 1997                          |              |               |  |
|-----|------|--------------------------------------|-------------------|----------------------|-----------------------------------|--------------|---------------|--|
| Day | Time | Wave Approach                        |                   | Width of Surf Zone,m | Water Characteristics at Pier End |              |               |  |
|     |      | Angle at Pier End<br>deg from True N | Primary Secondary |                      | Temp.,C                           | Density g/cc | Secchi Vis.,m |  |
| 1   | 0730 | 60                                   |                   | 134                  | 8.9                               | 1.0234       | 0.3           |  |
| 2   | 0655 | 55                                   |                   | 66                   | 8.3                               | 1.0168       | 0.6           |  |
| 3   | 0814 | 80                                   |                   | 50                   | 9.4                               | 1.0240       | 0.3           |  |
| 4   | 0700 | 110                                  |                   | 14                   | 10.0                              | 1.0240       | 2.1           |  |
| 5   | 0643 | none visible                         |                   | 14                   | 10.0                              | 1.0201       | 1.8           |  |
| 6   | 0715 | none visible                         |                   | 32                   | 10.0                              | 1.0236       | 2.1           |  |
| 7   | 0650 | none visible                         |                   | 18                   | 8.9                               | 1.0240       | 3.7           |  |
| 8   | 0725 | 60                                   | 30                | 85                   | 8.3                               | 1.0184       | 0.3           |  |
| 9   | 0707 | 60                                   |                   | 46                   | 7.8                               | 1.0182       | 0.9           |  |
| 9   | 0647 | 100                                  |                   | 14                   | 8.9                               | 1.0234       | 0.6           |  |
| 11  | 0620 | none visible                         |                   | 6                    | 8.9                               | 1.0242       | 0.9           |  |
| 12  | 0725 | 20                                   |                   | 9                    | 7.8                               | 1.0242       | 0.9           |  |
| 13  | 0620 | 30                                   |                   | 67                   | 7.2                               | 1.0240       | 2.1           |  |
| 14  | 0736 | 50                                   |                   | 46                   | 6.1                               | 1.0202       | 2.4           |  |
| 15  | 0735 | 40                                   |                   | 91                   | 6.1                               | 1.0186       | 2.1           |  |
| 16  | 0700 | 105                                  | 80                | 48                   | 7.8                               | 1.0234       | 0.6           |  |
| 17  | 0711 | 30                                   |                   | 120                  | 6.9                               | 1.0245       | 0.6           |  |
| 18  | 0705 | 20                                   |                   | 75                   | 6.1                               | 1.0242       | 0.6           |  |
| 19  | 0715 | 50                                   | 20                | 76                   | 4.4                               | 1.0232       | 0.3           |  |
| 20  | 0830 | 60                                   |                   | 52                   | 4.4                               | 1.0220       | 2.1           |  |
| 21  | 0640 | 25                                   |                   | 86                   | 5.3                               | 1.0228       | 0.6           |  |
| 22  | 0736 | 60                                   |                   | 54                   | 5.3                               | 1.0221       | 2.1           |  |
| 23  | 0707 | 105                                  |                   | 94                   | 6.9                               | 1.0240       | 0.9           |  |
| 24  | 0916 | 60                                   |                   | 70                   | 7.2                               | 1.0240       | 3.4           |  |
| 25  | 0655 | 90                                   |                   | 94                   | 7.8                               | 1.0240       | 0.6           |  |

# Water Levels

## 6

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Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

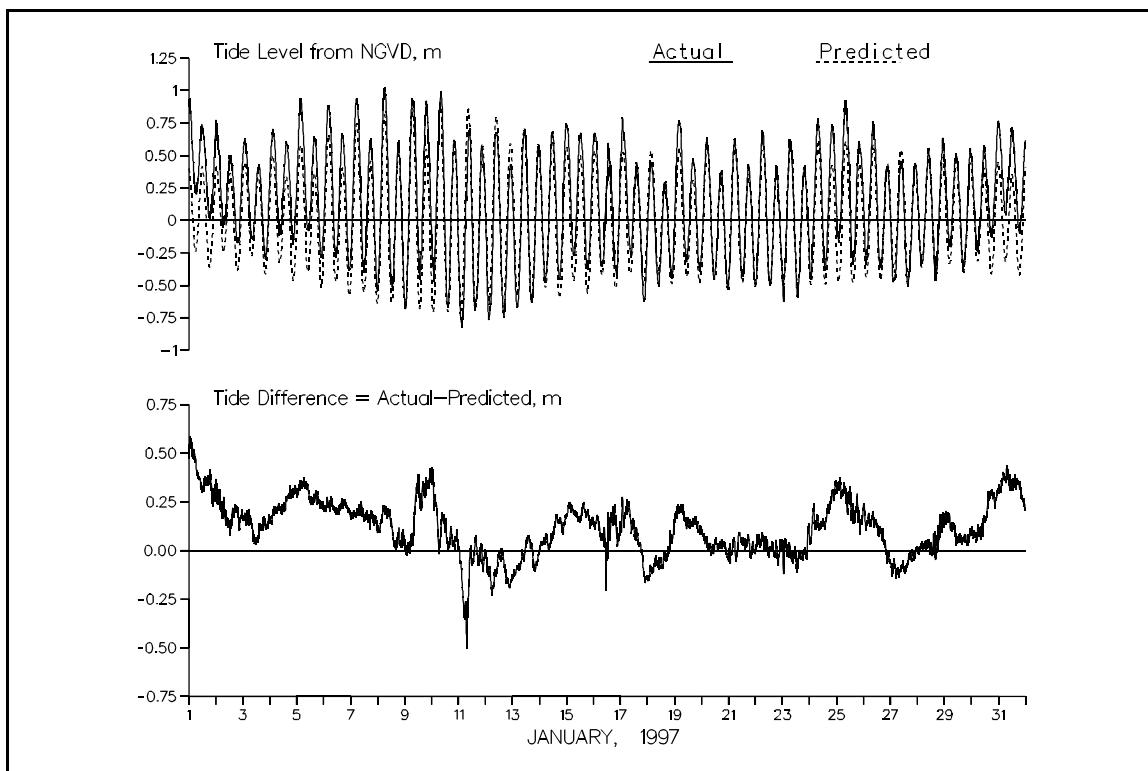


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

| JAN 1997 Tide Levels |      |      |     |      |       |       |      |       |      |      |     |      |       |       |      |       |
|----------------------|------|------|-----|------|-------|-------|------|-------|------|------|-----|------|-------|-------|------|-------|
| Day                  | High |      |     | Low  |       |       | Mean | Range | High |      |     | Low  |       |       | Mean | Range |
|                      | Time | m    | Day | Time | m     | Day   |      |       | Time | m    | Day | Time | m     | Day   |      |       |
| 1                    | 1136 | 0.74 | 1   | 0654 | 0.20  | 0.46  | 0.54 | 17    | 0148 | 0.80 | 16  | 2012 | -0.42 | 0.17  | 1.22 |       |
| 2                    | 0024 | 0.78 | 1   | 1906 | 0.00  | 0.34  | 0.78 | 17    | 1418 | 0.45 | 17  | 0936 | -0.28 | 0.09  | 0.73 |       |
| 2                    | 1312 | 0.50 | 2   | 0618 | -0.06 | 0.23  | 0.56 | 18    | 0254 | 0.45 | 17  | 2054 | -0.62 | -0.07 | 1.08 |       |
| 3                    | 0148 | 0.63 | 2   | 1918 | -0.18 | 0.22  | 0.81 | 18    | 1512 | 0.29 | 18  | 1012 | -0.50 | -0.10 | 0.80 |       |
| 3                    | 1424 | 0.43 | 3   | 0918 | -0.15 | 0.13  | 0.59 | 19    | 0430 | 0.77 | 18  | 2136 | -0.45 | 0.18  | 1.22 |       |
| 4                    | 0242 | 0.71 | 3   | 2018 | -0.30 | 0.21  | 1.01 | 19    | 1624 | 0.48 | 19  | 1042 | -0.32 | 0.09  | 0.80 |       |
| 4                    | 1448 | 0.61 | 4   | 0848 | -0.12 | 0.25  | 0.73 | 20    | 0448 | 0.64 | 19  | 2248 | -0.40 | 0.11  | 1.03 |       |
| 5                    | 0324 | 0.94 | 4   | 2112 | -0.19 | 0.38  | 1.12 | 20    | 1736 | 0.39 | 20  | 1118 | -0.45 | -0.03 | 0.84 |       |
| 5                    | 1536 | 0.64 | 5   | 1024 | -0.08 | 0.27  | 0.73 | 21    | 0536 | 0.63 | 20  | 2336 | -0.53 | 0.05  | 1.17 |       |
| 6                    | 0430 | 0.89 | 5   | 2124 | -0.29 | 0.30  | 1.18 | 21    | 1754 | 0.43 | 21  | 1230 | -0.44 | -0.02 | 0.87 |       |
| 6                    | 1624 | 0.66 | 6   | 1106 | -0.29 | 0.19  | 0.95 | 22    | 0624 | 0.69 | 21  | 2348 | -0.51 | 0.08  | 1.21 |       |
| 7                    | 0512 | 0.94 | 6   | 2312 | -0.38 | 0.27  | 1.33 | 22    | 1818 | 0.42 | 22  | 1306 | -0.50 | -0.05 | 0.92 |       |
| 7                    | 1818 | 0.63 | 7   | 1142 | -0.41 | 0.13  | 1.04 | 23    | 0642 | 0.63 | 23  | 0042 | -0.62 | 0.05  | 1.25 |       |
| 8                    | 0624 | 1.02 | 7   | 2348 | -0.55 | 0.24  | 1.57 | 23    | 1936 | 0.43 | 23  | 1324 | -0.59 | -0.07 | 1.02 |       |
| 8                    | 1848 | 0.62 | 8   | 1306 | -0.53 | 0.03  | 1.14 | 24    | 0712 | 0.78 | 24  | 0112 | -0.46 | 0.19  | 1.24 |       |
| 9                    | 0642 | 0.94 | 9   | 0048 | -0.69 | 0.16  | 1.63 | 24    | 2000 | 0.74 | 24  | 1354 | -0.38 | 0.19  | 1.12 |       |
| 9                    | 1930 | 0.92 | 9   | 1348 | -0.46 | 0.26  | 1.38 | 25    | 0748 | 0.93 | 25  | 0200 | -0.17 | 0.37  | 1.10 |       |
| 10                   | 0830 | 1.00 | 10  | 0200 | -0.48 | 0.30  | 1.47 | 25    | 1954 | 0.61 | 25  | 1424 | -0.34 | 0.17  | 0.95 |       |
| 10                   | 2006 | 0.62 | 10  | 1448 | -0.67 | 0.02  | 1.30 | 26    | 0818 | 0.76 | 26  | 0236 | -0.34 | 0.22  | 1.10 |       |
| 11                   | 1000 | 0.71 | 11  | 0306 | -0.83 | -0.09 | 1.53 | 26    | 2036 | 0.42 | 26  | 1524 | -0.37 | 0.02  | 0.79 |       |
| 11                   | 2036 | 0.57 | 11  | 1418 | -0.66 | -0.06 | 1.23 | 27    | 0924 | 0.46 | 27  | 0236 | -0.48 | -0.03 | 0.94 |       |
| 12                   | 0918 | 0.68 | 12  | 0248 | -0.77 | -0.04 | 1.45 | 27    | 2148 | 0.43 | 27  | 1548 | -0.51 | -0.03 | 0.94 |       |
| 12                   | 2230 | 0.43 | 12  | 1618 | -0.75 | -0.14 | 1.18 | 28    | 0948 | 0.56 | 28  | 0400 | -0.34 | 0.08  | 0.89 |       |
| 13                   | 1048 | 0.69 | 13  | 0412 | -0.68 | 0.01  | 1.37 | 28    | 2230 | 0.64 | 28  | 1612 | -0.47 | 0.10  | 1.10 |       |
| 13                   | 2300 | 0.57 | 13  | 1642 | -0.63 | -0.03 | 1.20 | 29    | 1006 | 0.52 | 29  | 0518 | -0.21 | 0.16  | 0.73 |       |
| 14                   | 1130 | 0.69 | 14  | 0454 | -0.48 | 0.10  | 1.17 | 29    | 2300 | 0.56 | 29  | 1706 | -0.36 | 0.08  | 0.91 |       |
| 14                   | 2348 | 0.75 | 14  | 1742 | -0.46 | 0.16  | 1.21 | 30    | 1124 | 0.58 | 30  | 0524 | -0.25 | 0.16  | 0.83 |       |
| 15                   | 1218 | 0.68 | 15  | 0606 | -0.28 | 0.21  | 0.95 | 30    | 2354 | 0.76 | 30  | 1748 | -0.13 | 0.31  | 0.90 |       |
| 16                   | 0054 | 0.68 | 15  | 1848 | -0.38 | 0.17  | 1.06 | 31    | 1218 | 0.71 | 31  | 0642 | 0.04  | 0.38  | 0.67 |       |
| 16                   | 1312 | 0.60 | 16  | 0730 | -0.36 | 0.07  | 0.96 |       |      |      |     |      |       |       |      |       |

# Bathymetry

## 7

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A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using a Trimble 4000 SSE GPS for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in December 1996 and the survey(s) in January 1997 on profile line 188, located 517 m south of the pier.

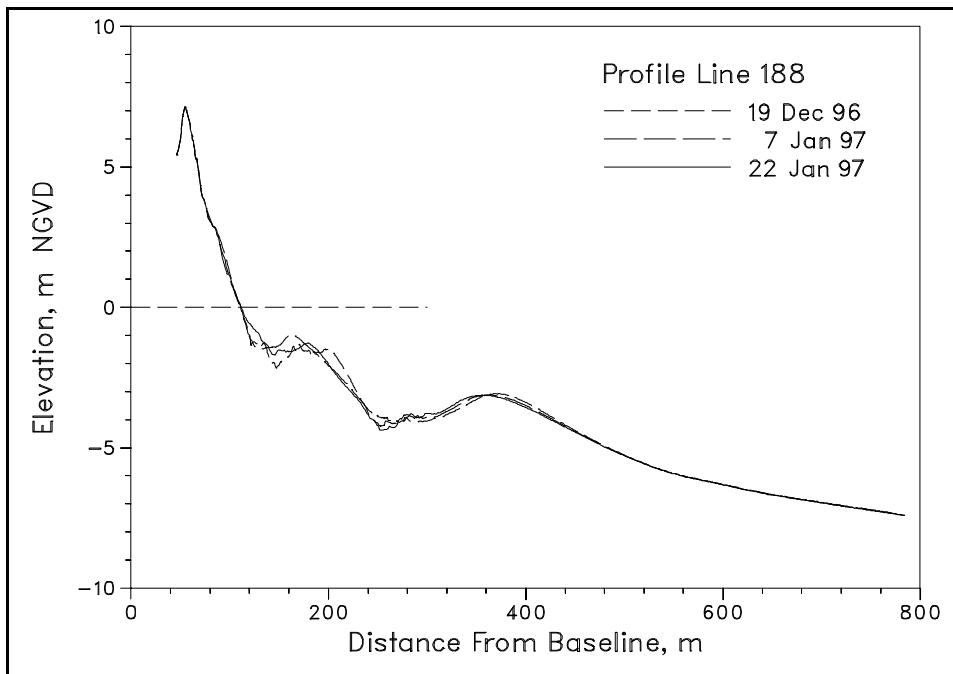


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1997. Cross-hatched areas indicate changes to the annual envelope which occurred in January.

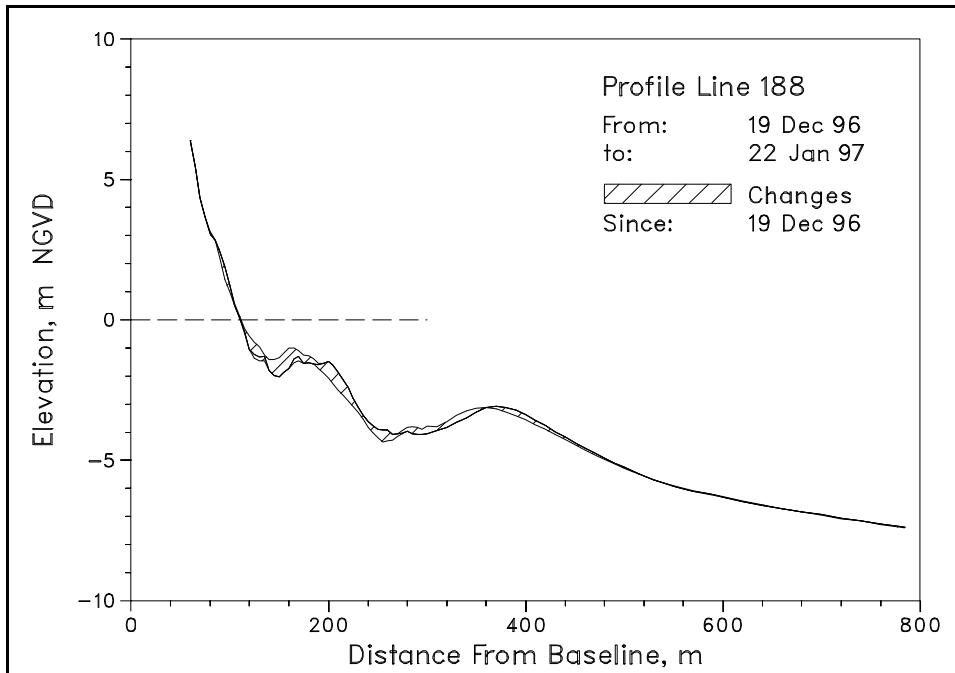
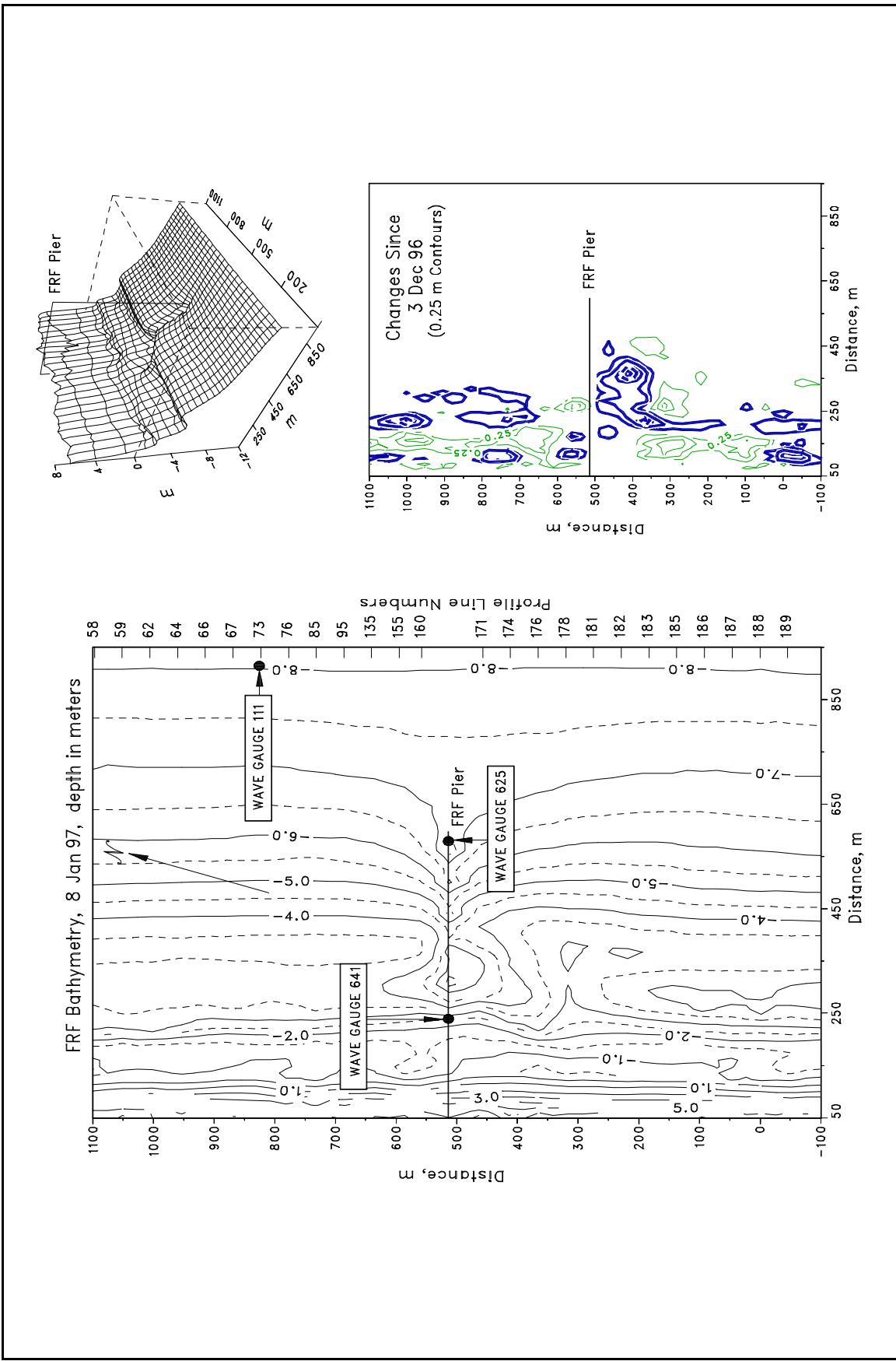


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 8 January. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



# Special Events

## 8

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A. Storm Data Collection. The following list identifies times when the wave height  $H_{mo}$  at the seaward end of the pier exceeded 2 m.

| <u>Start</u>  | <u>End</u>    |
|---------------|---------------|
| ** Dec (0000) | ** Dec (0000) |

B. Storm Synopsis.

Northeasterly winds were funneled between a Canadian high pressure system and a low pressure system over Cape Hatteras. Winds intensified as the low pressure system moved along the North Carolina coast and began moving out to sea by the morning of \*\* January. Maximum onshore winds (NE) reached \*\* m/s at 0000 EST on \*\* January. The minimum atmospheric pressure was \*\*\* mb. The maximum  $H_{mo}$ , at gauge 630, reached \*.\* m ( $T_p=**.*$  s) at 0000 EST on \*\* January. There was \* mm of precipitation.